ExoPlanet Exploration Program

Technology Development for Exoplanet Missions (TDEM)

Technology Milestones

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Agenda

- Background on Technology Plans, Milestones, and TDEM
  - What does a Milestone represent?
- Structure of Milestone Whitepapers
  - An illustrated example: a Milestone Whitepaper Template
- "Didn't I already propose my Milestones?"
  - Perhaps, but what you might have called a Milestone in your proposal, might not be a Milestone as described here. Your whitepaper may consolidate some of your proposed Milestones and will quantify the success criteria.
- Timeline for Milestone Whitepaper Reviews
  - The Technology Assessment Committee (TAC)
  - The review process
  - Your reviewers

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The Road to Phase A

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- Science goal / Science requirements
  - Detect spectra of Earth-like planets in habitable zones around N nearby stars, in a given wavelength band, with R=40 and a signal-to-noise > 10 for faintest object
- Detailed mission concept
  - Coronagraph, Starshade, Interferometer…
- Performance requirements & error budget
  - Numerous technologies required, e.g. starlight suppression
    - Laboratory demonstrations / performance demonstrations
    - Model validation
  - Science performance predictions from validated models
- Iterate mission concept, error budget, technologies, as needed

Readiness to enter Phase A

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- The set of critical technology must be demonstrated
  - Without this technology, the mission is not possible
  - The technology works – proceed to Phase A
  - The technology doesn't work – iterate mission concept
- Milestones document that the technology is ready
  - Works every time
  - Within a factor of 10 of flight performance requirements
  - Backed up by an error budget
- Failure to complete a milestone should halt a mission concept entering Phase A

Milestone Process

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- Milestone Whitepaper
  - A detailed document describing the goal of the milestone demonstration and the criteria by which it will be met
  - It is the contract that describes the work to be undertaken
  - Signed by the PI, the Exoplanet Program representative, and NASA HQ
- Lawson will guide you through the process on behalf of the Exoplanet Program
  - Assist in editing the Whitepaper, preparing it for review, if appropriate
  - Coordinate the date of the review with the independent panel
  - Moderate the review on behalf of the PI
  - Track issues to be resolved
  - Negotiate changes and coordinate the signing of the final draft
- Milestones will be reviewed and approved by the ExEP Technology Assessment Committee (TAC), appointed by NASA HQ and the Exoplanet Exploration Program.

ExEP Technology Assessment Committee

- Vern Weyers (Chair)
- Alan Boss (Carnegie Institution of Washington)
- David Mozurkewich (Seabrook Engineering)
- Anand Sivaramakrishnan (STScI)
- Richard Harms (consultant)
- Joe Pitman (Exploration Sciences)
- Lisa Poyneer (LLNL)
- Richard Capps (JPL/Caltech)

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Example

- An illustrated Milestone Whitepaper from
- http://exep.jpl.nasa.gov/technology/

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An Example Timeline (I)

- Lawson will schedule a review by telecon about 1 or 2 months in advance of the anticipated review date
  - www.doodle.com
- The PI will send a draft whitepaper to the TAC ~2 weeks prior to the review
- The panel will compile a bulleted or numbered list of detailed comments in a single Word document and email it for consideration of the PI about 3 days prior to the review
- The PI will send his responses to the panel just prior to the telecon; the Word document itself is edited and returned.

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An Example Timeline (II)

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- The telecon will last about 1.5 – 2.0 hours. Most issues will already have been resolved by the previous exchanges.
  - The list of comments and responses will be read through.
  - Most discussions will simply be to clarify the issues and concerns
  - Changes to the text will be negotiated and noted
- About 2 or 3 weeks after the review, a revised draft will be sent to the panel, along with the edited Word document noting where the changes have occurred.
- If the panel is in agreement (by email) that all issues have been resolved, the panel will recommend that the document be signed, and the signature page will be circulated.

The Milestone Report and Review

- The Milestone Report is almost a carbon copy of the Whitepaper, repeating all that content but now also including
  - Laboratory and/or Modeling Results
    - Show all the required experimental / analysis data
    - The criteria are stepped through and shown to be met
  - Conclusion
    - Because all the criteria have been met, the milestone has now been demonstrated
- The Report review process is essentially the same as the Whitepaper review

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Backup

Suggestions

- Make it easy for the review panel to help you.
- Provide a detailed and clear description of the milestone experiment and its relevance to flight
  - Include a diagram of the experimental layout and components. Provide photographs if possible.
- Explain the path forward to future milestones and the overall technology plan or roadmap
- Provide background material and references from the refereed literature
- Make absolutely sure the success criteria are unambiguous and not needlessly restrictive
- Do your **utmost** to resolve all major issues and/or misunderstandings *prior* to the date of the review

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(Example) Milestone Success Criteria

- Define the
  - Wavelength and minimum bandwidth to be used
  - Performance metric (i.e. starlight rejection)
  - Threshold performance required for success
    - Maximum mean value calculated over an angular region, or as a function of time for a given period
  - Duration of the tests or time-series of data
    - Each time series will be *n*-hours or more
  - Number of repetitions of the experiment
    - Typically three repetitions
  - The time between experiments
    - Typically 48 hours
- For model validation, provide model fidelity goals based on error budget tolerances

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References and Examples

- Technology Readiness Levels as defined in NASA Procedural Requirements NPR 7120.8
  - http://nodis3.gsfc.nasa.gov/displayDir.cfm?Internal_ID=N_PR_7120_0008_&page_name=AppendixJ
- Previous TDEM Milestone Whitepapers
  - http://exep.jpl.nasa.gov/technology/

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Broader Definition of Milestones

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- Milestones are measured steps to verify technology readiness tied to the performance of a specific mission. It can be one or more elements of the following:

Based on a mission error budget w/ sub-system allocations:

1. **Demonstrate technology through laboratory experiments to quantified goals traceable to an error budget allocation**
2. **Validate technology demonstration models & error budget sensitivities**
3. **Apply validated models to mission analyses and error budget to demonstrate that the on-orbit performance is achieved**